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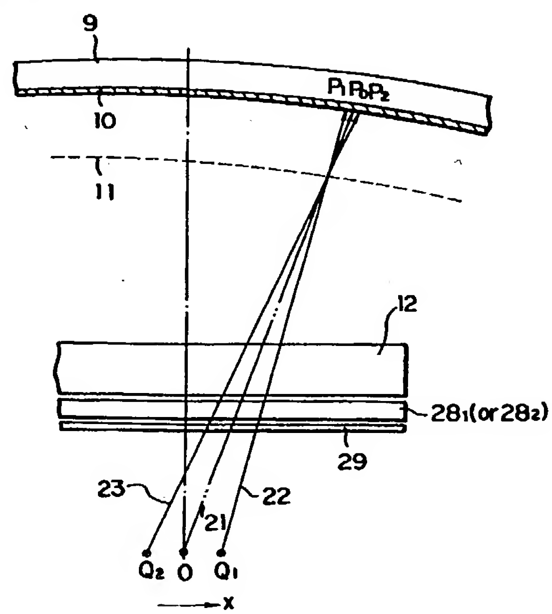
(54) Methods of and apparatus for exposing colour cathode ray tubes.

(57) In order to form a fluorescent surface on a panel (9) of a colour cathode ray tube, a light source is placed at a number of positions (Q_2, O, Q_1) and exposed at each position to a photoresist film (10) on the inside surface of the panel to form prescribed stripe width patterns using a transmission light intensity distribution formed by superposed plural Fresnel diffraction waveforms. Exposure is effected in the different positions via different correction lens systems (12, 28_1, 28_2) selected to correspond to the exposure at the various light source positions and the absolute value of the transmission light intensity distribution and the derivative (dI/dx) of the transmission light intensity distribution at positions corresponding to the edge of the stripe width pattern are optimised over the entire inside surface of the panel.



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METHODS OF AND APPARATUS FOR EXPOSING COLOUR CATHODE RAY TUBES

This invention relates to methods of and apparatus for exposing colour cathode ray tubes.

In colour cathode ray tubes it is conventional to form or provide a fluorescent surface, such as a colour fluorescent surface of stripe pattern wherein black stripes which comprise a light absorbing layer are formed between colour fluorescent stripes of red, green and blue. This can be done by a known exposure process in which a photoresist film is first applied to an inside surface of a panel of a cathode ray tube and then dried. Then, an aperture grill, which is a colour selecting electrode with a number of beam transmission holes or apertures in the shape of slits which are ranged in a desired pitch, is used as an optical mask and ultraviolet exposure is accomplished through the aperture grill. The exposed photoresist material is then developed so as to form a number of stripe-shaped resist layers in positions corresponding to the various colours. The ultraviolet exposure is accomplished three times, one each for the red, green and blue colours, by shifting the position of the exposure light to light source positions of the different colours. Then, carbon slurry is applied to the whole surface of the tube, including the resist layer, and dried. The resist layer is then lifted off, together with a carbon layer above it, so as to produce carbon stripes of the prescribed pattern, in other words black stripes. A first fluorescent slurry of green colour, for example, is applied thereto and exposed, and a development treatment is then carried out so as to produce a green fluorescent stripe on the so-called blank photoresist stripe width between the prescribed carbon stripes. By way of similar processes, blue and red fluorescent stripes are formed in other photoresist stripes so that the intended colour fluorescent surface is obtained.

In such known exposure methods, depending upon the optical dimension of the colour cathode ray tube, the light intensity distribution transmitted through the slits of the aperture grill may be subject to Fresnel diffraction having a waveform distribution such as is illustrated in Figure 1A

of the accompanying drawings, which is a graph of the transmission light intensity I plotted against position x. When this occurs, so as to obtain a photoresist stripe required by the design of the cathode ray tube, in other words, so as to obtain a width W of a blank photoresist stripe 3 between carbon stripes 2 as shown in Figure 1B, the edge of the stripe of the photoresist stripe is produced at positions depending upon the derivative dI/dx of the transmission light intensity distribution, which is extremely small. The derivative of the photo crosslinking distribution of the photoresist film becomes small and thus the edge becomes uneven or rough to a significant extent, as shown in Figure 1B, and unevenness of colour will be produced macroscopically, which will deteriorate the quality of the colour cathode ray tube.

In order to eliminate these disadvantages, in a known method illustrated in Figure 2 the position of the exposure light source is moved laterally from a reference position O for the green, blue or red colour to positions Q1 and Q2 which are laterally offset in opposite directions from the reference position O. Then, ultraviolet rays 4 and 5 are irradiated from the positions Q1 and Q2, respectively. Such exposure method is referred to as "the two point light source exposure method". In such method, the transmission light intensity distribution 8 comprises two superposed Fresnel diffraction waveforms 6 and 7 as illustrated in Figure 3 and the intended photoresist stripe width W is obtained therefrom. In Figure 2, a panel 9 with an inside surface coated by a photoresist film 10 is exposed via an aperture grill 11 and a correction lens 12 is mounted between the ultraviolet exposure source and the panel 9 as shown. The correction lens 12 approximately provides that the light path will approximate the actual path of travel of the electron beam.

However, in the known two point light source exposure method, the superposed transmission light intensity distribution 8, illustrated by a dashed line in Figure 3, is not optimised over all of the inside surface of the panel 9, as shown by the dip in the centre of the curve shown in Figure 3, and this method has the following disadvantages.

Depending upon the optical dimensions of the colour cathode ray tube, there may be regions in the tube at which it is impossible properly to manufacture the desired stripes. Since the derivative dI/dx of the transmission light intensity distribution 8 becomes small in some regions of

the inside surface of the panel, the derivative dQ/dx of the photo crosslinking distribution of the photoresist film becomes small and, thereby, the variation of the photoresist stripe width becomes significant, as illustrated in Figure 1B, and the quality of the tube deteriorates. Variations caused by materials such as the slit width of the aperture grill or the distance between the aperture grill and the panel (Bar-Height) affects directly the generation of unevenness in colour and the reproduction yield of tubes becomes lowered.

Figures 6A to 6F illustrate the transmission light intensity distribution (solid lines) and the derivative dI/dx thereof (broken lines) at arbitrary positions (x_i, y_i) on the inside of the panel surface obtained by the known two point light source exposure method. Figures 6A to 6F correspond, respectively, to a centre upper position (x_i, y_i = 1, 180), the centre (x_i, y_i = 1,1), an intermediate upper position (x_i, y_i = 127, 180), an intermediate centre position (x_i, y_i = 127, 1), a peripheral upper position (x_i, y_i = 255, 180) and a peripheral centre position (x_i, y_i = 155, 1). As is clearly shown in Figures 6A to 6F, the derivative dI/dx of the transmission light intensity distribution at positions corresponding to the edge of the photoresist stripe width W is large in the centre and peripheral positions but is small in intermediate positions, whereby manufacture becomes impossible or variations of the photoresist stripe width become significant at intermediate positions.

The present invention provides a method of exposing a colour cathode ray tube, wherein

plural exposure light source positions are each exposed to a prescribed stripe width on a panel using a transmission light intensity distribution obtained by superposition of plural Fresnel diffraction waveforms,

a correction lens is selected in correspondence with the exposure at various light source positions, and

the absolute value of the transmission light intensity distribution or amount of exposure and the derivative of the transmission light intensity distribution or exposure amount at positions corresponding to the edge of the stripe width are optimised over the entire inside surface of the panel.

Also, the present invention provides a method of exposing a colour cathode ray tube to form stripe patterns thereon, the method comprising the steps of

exposing a stripe, through a first lens system and a shadow mask, to a light source at a first position,

exposing said stripe, through a second lens system, to a light source at a second position offset from the first position, the second lens system differing from the first lens system, and

exposing said stripe, through a third lens system, to a light source at a third position which is offset from the first and second positions, the third lens system differing from the first and second lens systems so as to obtain a substantially uniform light intensity distribution and the derivative of the transmission light intensity or amount of exposure at the edge of the stripe being optimised over the entire inside surface of an area of the tube.

Further, the present invention provides apparatus for exposing a colour cathode ray tube through a shadow mask to form stripe patterns thereon, the apparatus comprising a light source, a first lens system through which the light source can be projected from a first position to expose a stripe pattern, a second lens system through which the light source can be projected from a second position to expose the stripe pattern, and a third lens system through which the light source can be projected from a third position to expose the stripe pattern so as to form the stripe pattern with straight edges.

A preferred embodiment of the present invention described in detail hereinbelow provides an exposure method and apparatus for a colour cathode ray tube wherein the derivative dI/dx of the transmission light intensity distribution or the exposure amount and the absolute value of the transmission light distribution I or the exposure amount are at least in substance uniform throughout the inside surface of the panel and the derivative dQ/dx of the photo crosslinking distribution of the photoresist film and the absolute value of the photo crosslinking distribution Q are completely optimised such that a fluorescent surface having a fine pitch can be exposed and obtained. To this end, during the exposure of a cathode ray tube, plural positions of an exposure light source are utilised and a film on the panel inside surface is exposed to prescribed stripe widths using the transmission light intensity distribution by superposing plural Fresnel diffraction waveforms using correction lens systems including correction lens and light intensity correction filters which are selected depending on the exposure at various light source positions. The absolute value of the

transmission light intensity distribution or the exposure amount and the derivative dI/dx of the transmission of the transmission light intensity distribution or exposure amount at positions corresponding to the edge of the stripe width are optimised throughout the inside surface of the panel. The desired stripe width can be exposed throughout the inside surface of the panel. Consequently, for example, a fine pitch cathode ray tube having a fluoresecent surface with fine pitch can be manufacted by mass production techniques.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which like references designate like items throughout, and in which:

Figure 1A is a graph of transmission light intensity distribution;

Figure 1B is a plan view of a stripe exposed by transmission light;

Figure 2 is a diagrammatic view illustrating a known two point light exposure method;

Figure 3 is a graph illustrating a superposed transmission light intensity distribution produced by the known method;

Figure 4 is a diagram illustrating an exposure method and apparatus embodying the present invention;

Figure 5 is a graph of a superposed transmission light intensity distribution which is produced by the method embodying the present invention;

Figures 6A to 6F are graphs illustrating the transmission light intensity distribution and the derivative thereof as produced at arbitrary positions on an inside surface of a panel of a colour cathode ray tube by the known method; and

Figures 7A to 7F are graphs illustrating the transmission light intensity distribution and the derivative thereof as produced at arbitrary positions on an inside surface of a panel of a colour cathode ray tube by the method embodying the present invention.

Figures 4 and 5 illustrate an embodiment of the present invention wherein the panel 9 has an inside surface which is to be coated by a photoresist film 10, an aperture grill 11 is mounted adjacent the panel 9, and a correction lens 12 is mounted for approximating the light path during exposure to the actual path of travel of the electron beam. The embodiment illustrates the exposure of a photoresist film 10 to form a black

stripe and Figure 4 illustrates the exposure of one stripe corresponding to the colour green. In this embodiment, so as to expose one strip or stripe, the exposure light source is moved to three different positions in the x direction, namely to the reference position O and to offset lateral positions Q_1 and Q_2, and three different ultraviolet rays 21, 22 and 23 are irradiated from the positions O, Q_1 and Q_2 respectively. As illustrated in Figure 5, the Fresnel diffraction waveforms 24, 25 and 26 produced by the ultraviolet rays 21, 22 and 23 are superimposed into a transmission light intensity distribution 27 shown by a dashed line, and the exposure is performed by the light intensity distribution 27. This method is referred to as a "three point light source exposure method".

When the exposure is performed at the light source positions Q_1 and Q_2, in addition to the use of the correction lens 12, second correction lenses 28_1 or 28_2 are selectively inserted so as to optimise the superposition of both of the Fresnel diffraction waveforms 25 and 26 throughout (i.e. over the whole of) the inside surface of the panel 9, that is to enlarge the derivative dI/dx of the superposed transmission light intensity distribution 27 at positions corresponding to the edges of the stripe width W throughout the inside surface of the panel. The correction lenses 28_1 and 28_2 are different from each other and have different lens characteristics, and the correction lens 28_1 and the correction lens 12 are combined and utilised when exposing from the light source position Q_1. On the other hand, the correction lens 12 and the correction lens 28_2 are combined when exposing from the light source position Q_2. When the exposure is performed from the light source position O, the correction lens 12 and a light intensity correction filter 29 are used and the intensity distribution at the centre pattern of the superposed transmission light intensity distribution 27 is controlled by the light intensity correction filter 29 so a to ensure that the absolute value of the transmission light intensity distribution 27 will be made uniform throughout the inside surface of the panel.

The correction lenses 28_1 and 28_2 are selected so that they correspond to the exposure of the light source positions Q_1 and Q_2, whereby the waveforms of the transmission light intensity diffraction waveforms 25 and 26 are optimised throughout the inside surface of the panel 9. Consequently, the derivative dI/dx at positions corresponding to the edge of the stripe width to be exposed become large and a photoresist stripe width is

obtained which has no unevenness throughout the inside surface of the panel. For the exposure from the light source position O, the absolute value of the transmission light intensity distribution 27 is made uniform throughout the inside surface of the panel 9 by the light intensity correction filter 29 and over-exposure may be prevented.

As an example, for the photoresist film 10, use may be made of a PVP photo sensitive agent composed of polyvinyl pyrrolidone (PVP) and 4, 4'-diazistilbene-2, 2'-sodium diasulphonate (DAS) and having a reciprocal law failure characteristics (decrease of photo crosslinking distribution in the region of low light intensity) which recently have been anounced. However, if the PVP photosensitive agent is overexposed, photo crosslinking points increase and cannot completely be removed during the lifting-off stage, but remain partially in the photoresist stripe.

On the other hand, a PVA photosensitive agent composed of polyvinyl alcohol (PVA) and ammonium dichromate (ADC) is generally used. This agent may produce unevenness in the exposure pattern based on light diffraction by over-exposure. However, since over-exposure is suppressed by the present method, this problem is at least in substance eliminated.

Figures 7A to 7F illustrate examples of the transmission light intensity distribution (solid lines) and the derivative dI/dx thereof (broken lines) at arbitrary positions (x_i, y_i) on the inside surface of the panel obtained by the exposure method embodying the present invention. Figure 7A shows the light intensity distribution and the derivative dI/dx at the centre upper position where x_i and y_i equal 1, 180. Figure 7B shows these quantities at the centre position where x_i, y_i equal 1, 1. Figure 7C shows them at the intermediate upper position where x_i, y_i equals 105, 180. Figure 7D corresponds to the intermediate centre position where x_i and y_i equal 105, 1. Figure 7E illustrates the peripheral upper position where x_i and y_i equal 255, 180 and Figure 7F illustrates the peripheral centre position where x_i, y_i equal 255, 1. It can be seen from Figures 7A to 7F that the derivative dI/dx, at positions corresponding to the edge of the stripe width W, becomes large throughout the centre, intermediate and peripheral positions of the panel inside surface. Consequently, the difficulty or impossibility of manufacture at the intermediate region, due to unevenness of the photoresist stripe width, is eliminated or at least greatly reduced.

Although three point light source exposures are described in the above example, it should be realised that the invention may also be applied to two point light source exposure and other multipoint light source exposure methods.

The light intensity correction filter is used to make the transmission light intensity through the inside surface of the panel as uniform as possible. Consequently, the filter may be selected to be suitable for exposure at the various light source positions.

According to the embodiment of the invention described above, a correction lens system is selected which corresponds to the exposure at various light source positions and the absolute values of the transmission light intensity distribution obtained by superposition of plural Fresnel diffraction waveforms and the derivative as well as the absolute value and the derivative of the photo crosslinking distribution based on the transmission light intensity distribution are optimised throughout the inside surface of the panel. Thus, a fluorescent surface with a fine pitch pattern can be formed, which is impossible by known methods. Since variations of the photoresist stripes width are reduced, the quality of the cathode ray tube is increased. Variations based on materials are absorbed and unevenness of the exposed stripe edge is eliminated or at least reduced, whereby the production yield is improved. Accordingly, the method embodying the invention allows the exposure of a fine pitch colour cathode ray tube having a colour fluorescent surface of a fine pitch pattern.

CLAIMS

1. A method of exposing a colour cathode ray tube, wherein plural exposure light source positions (O, Q_1, Q_2) are each exposed to a prescribed stripe width (W) on a panel (9) using a transmission light intensity distribution (27) obtained by superposition of plural Fresnel diffraction waveforms (24, 25, 26), a correction lens (28_1, 28_2) is selected in correspondence with the exposure at various light source positions, and the absolute value of the transmission light intensity distribution (I) or amount of exposure and the derivative (dI/dx) of the transmission light intensity distribution or exposure amount at positions corresponding to the edge of the stripe width are optimised over the entire inside surface of the panel (9).

2. A method of exposing a colour cathode ray tube to form stripe patterns thereon, the method comprising the steps of exposing a stripe, through a first lens system (12, 28_1) and a shadow mask (11), to a light source at a first position (Q_1), exposing said stripe, through a second lens system (12, 28_1), to a light source at a second position offset (Q_2) from the first position (Q_1), the second lens system (12, 28_2) differing from the first lens system (12, 28_1), and exposing said stripe, through a third lens system (12, 29), to a light source at a third position (O) which is offset from the first and second positions (Q_1, Q_2), the third lens system (12, 29) differing from the first and second lens systems (12, 28_1; 12, 28_2) so as to obtain a substantially uniform light intensity distribution and the derivative (dI/dx) of the transmission light intensity (I) or amount of exposure at the edge of the stripe being optimised over the entire inside surface of an area of the tube.

3. Apparatus for exposing a colour cathode ray tube through a shadow mask (11) to form stripe patterns thereon, the apparatus comprising a light source, a first lens system (12, 28_1) through which the light source can be projected from a first position (Q_1) to expose a stripe pattern, a second lens system (12, 28_2) through which the light source can be projected from a

second position (Q_2) to expose the stripe pattern, and a third lens system (12, 29) through which the light source can be projected from a third position (O) to expose the stripe pattern so as to form the stripe pattern with straight edges.

FIG. 1A

FIG. 1B

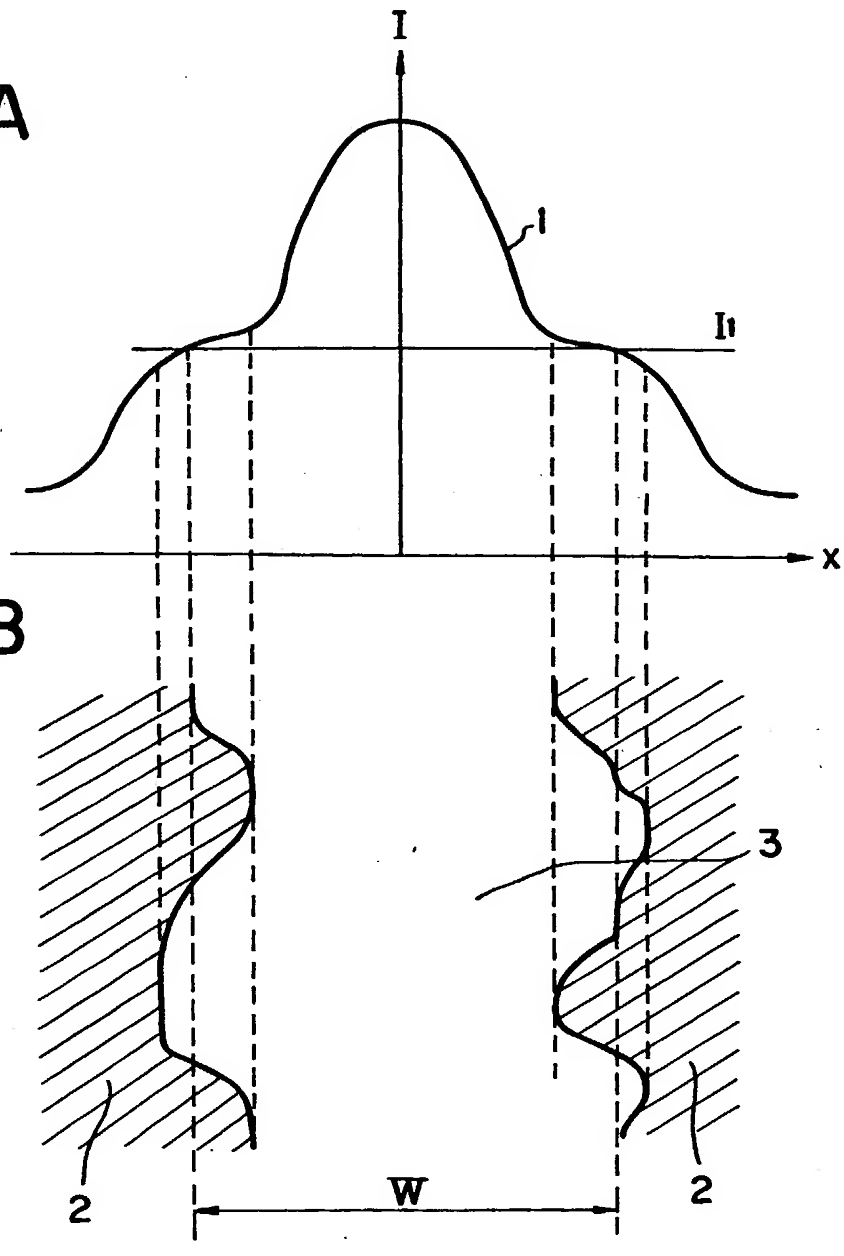


FIG. 2

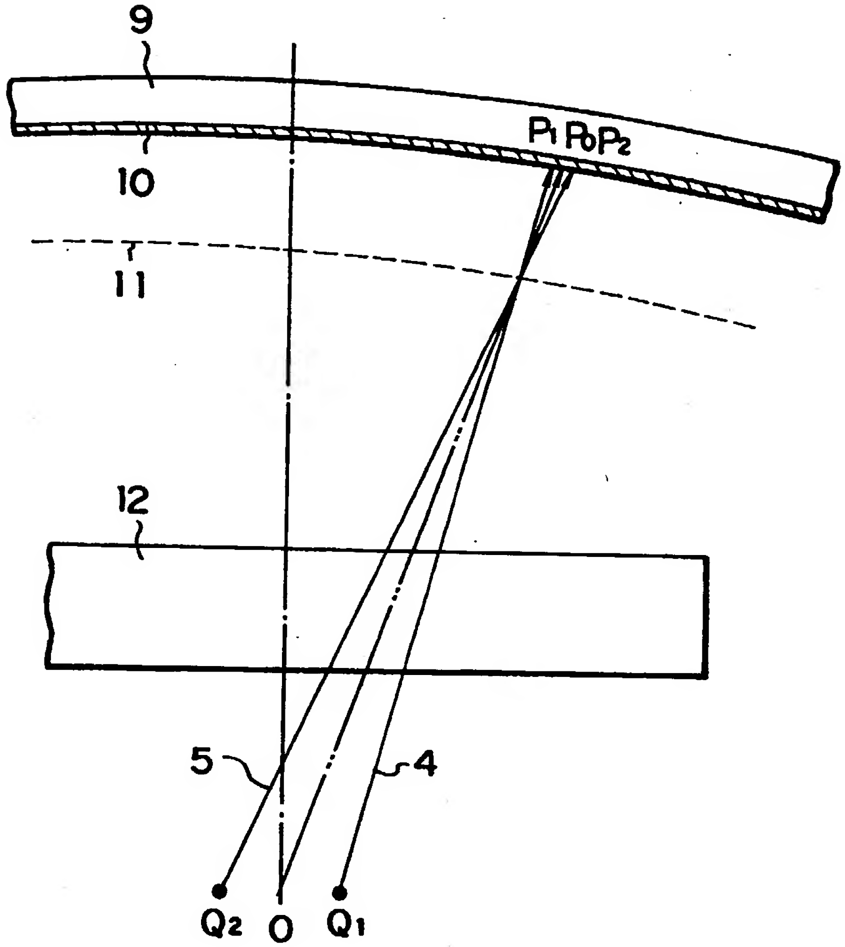


FIG. 3

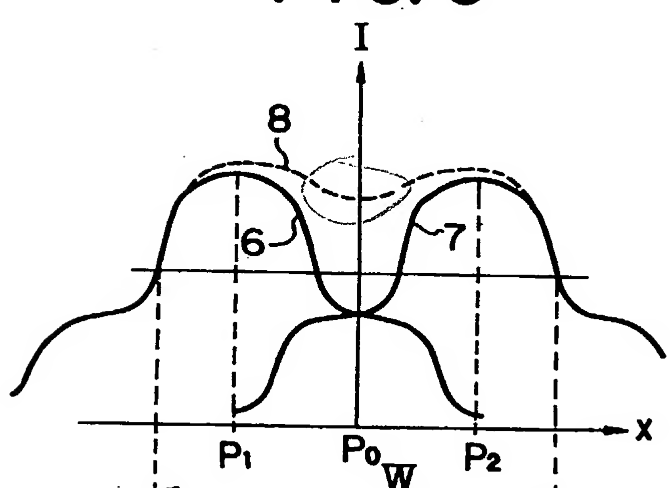


FIG.4

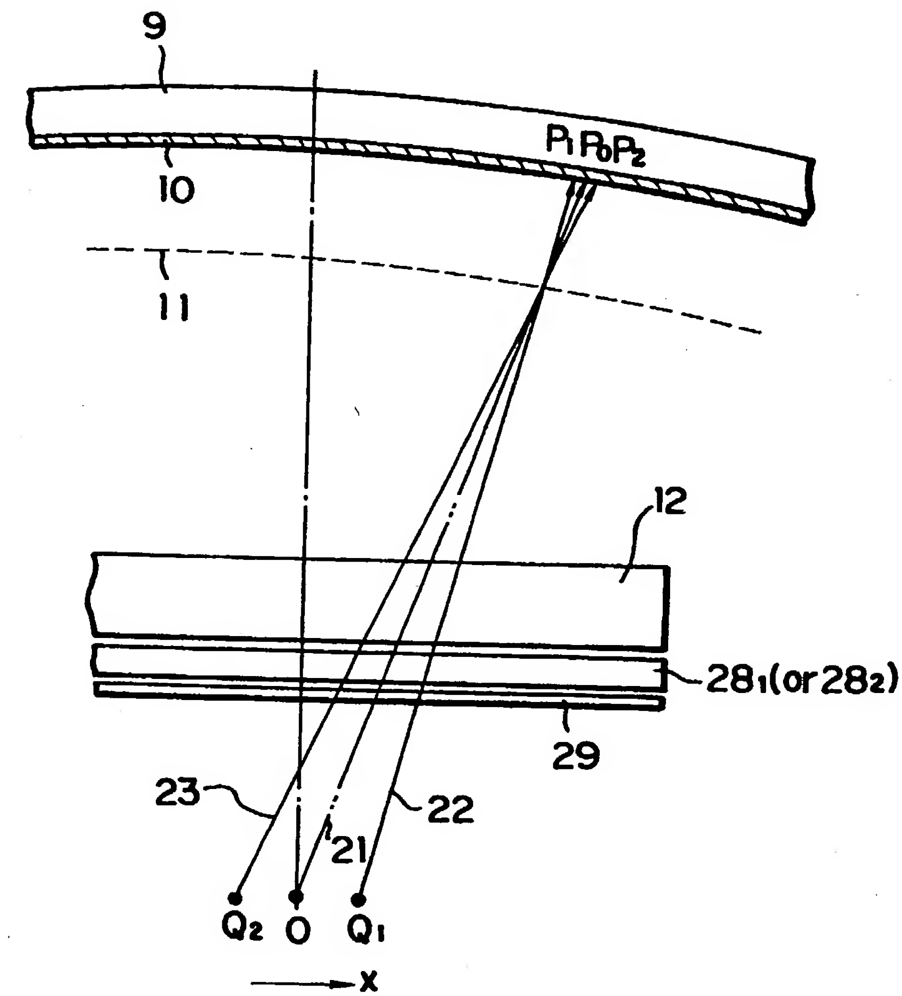

9
P1 P0 P2
10
11
12
28₁(or 28₂)
29
23
22
21
Q2 O Q1
x

FIG.5

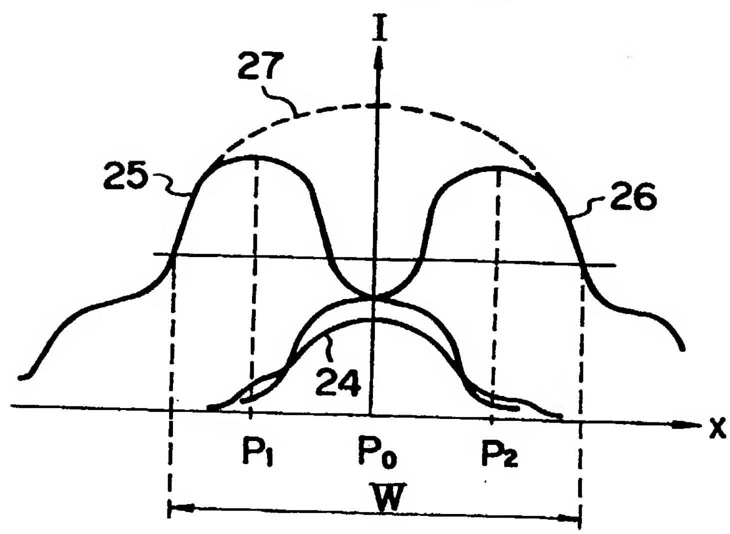

I
27
25
26
24
P1
P0
P2
W
x

FIG. 6A

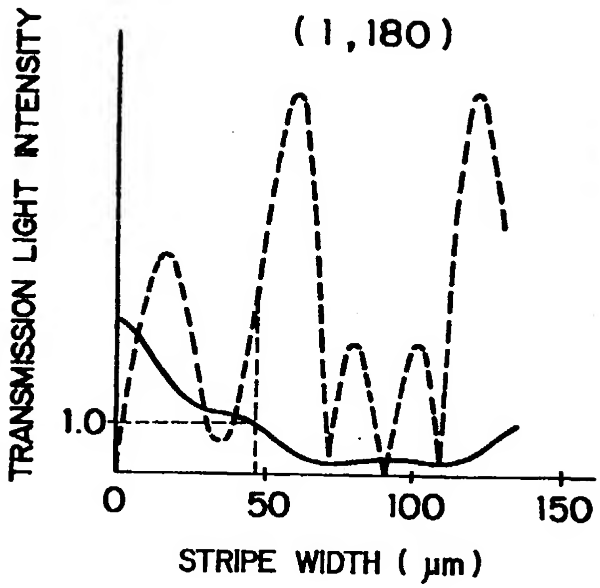


FIG. 6B

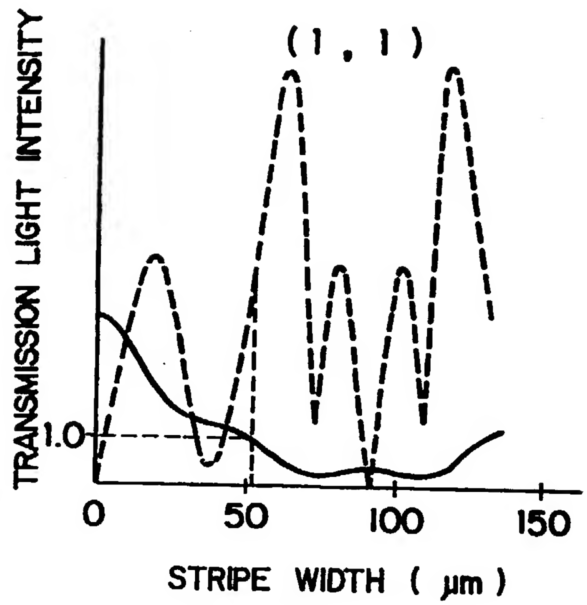


FIG. 6C

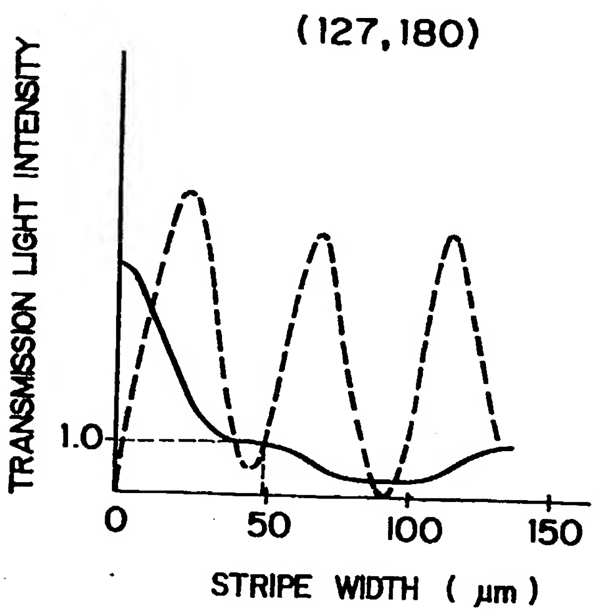


FIG. 6D

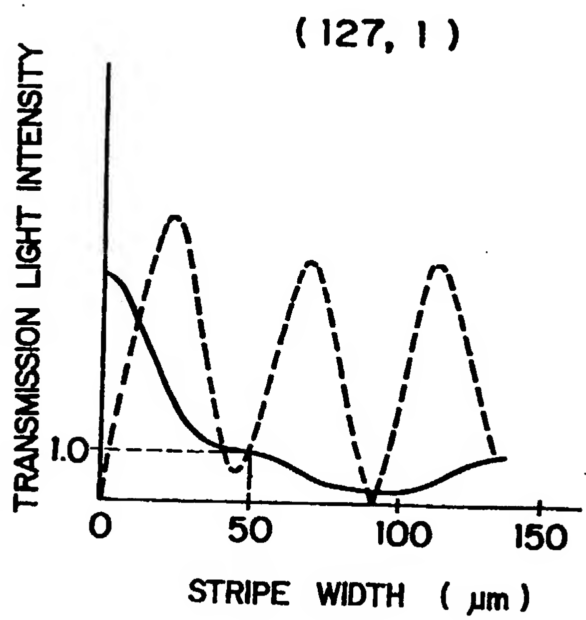
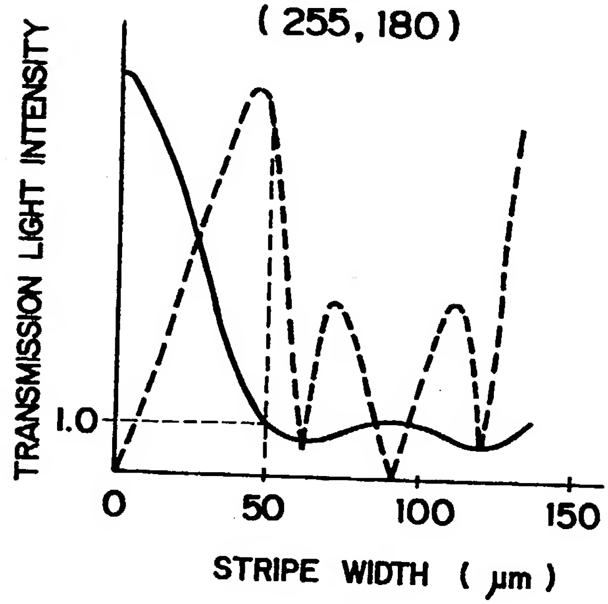
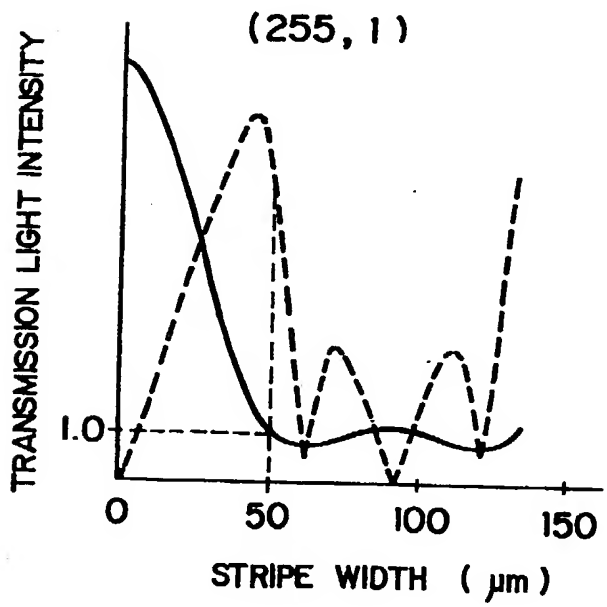


FIG. 6E



(255, 180)
TRANSMISSION LIGHT INTENSITY
1.0
0
50
100
150
STRIPE WIDTH (μm)

FIG. 6F



(255, 1)
TRANSMISSION LIGHT INTENSITY
1.0
0
50
100
150
STRIPE WIDTH (μm)

FIG. 7A

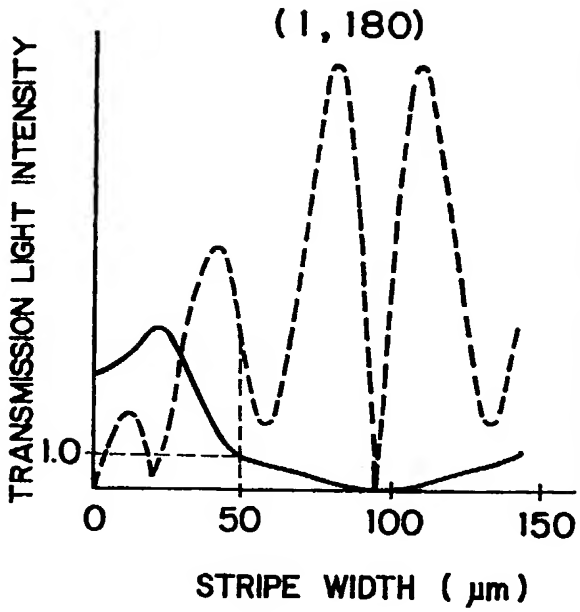


FIG. 7B

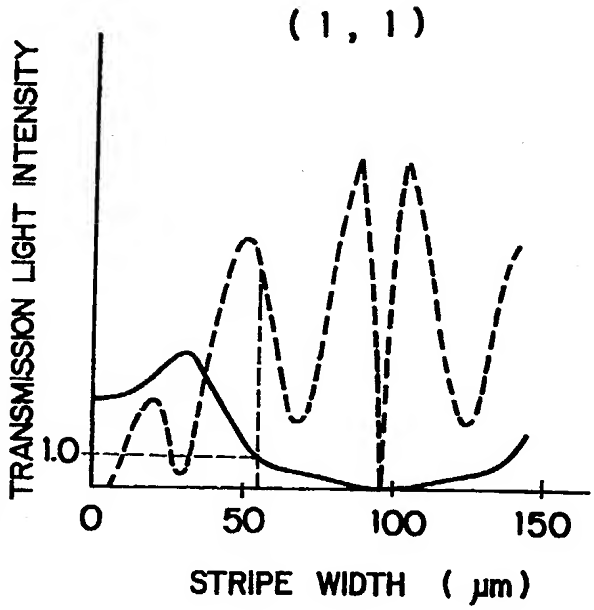


FIG. 7C

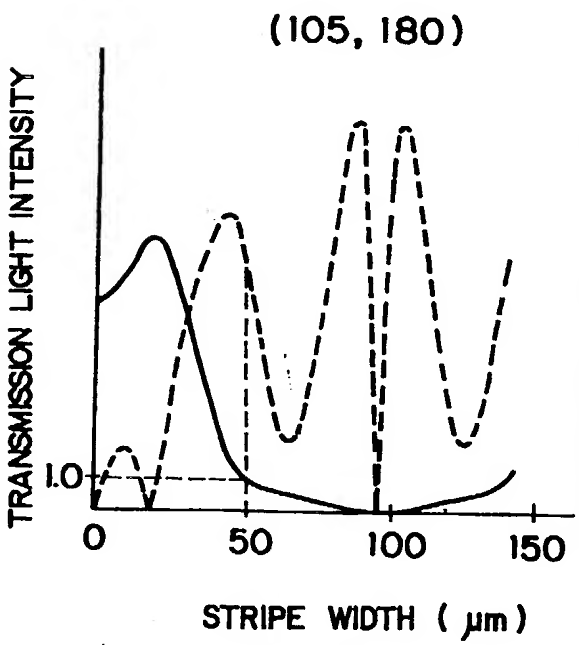


FIG. 7D

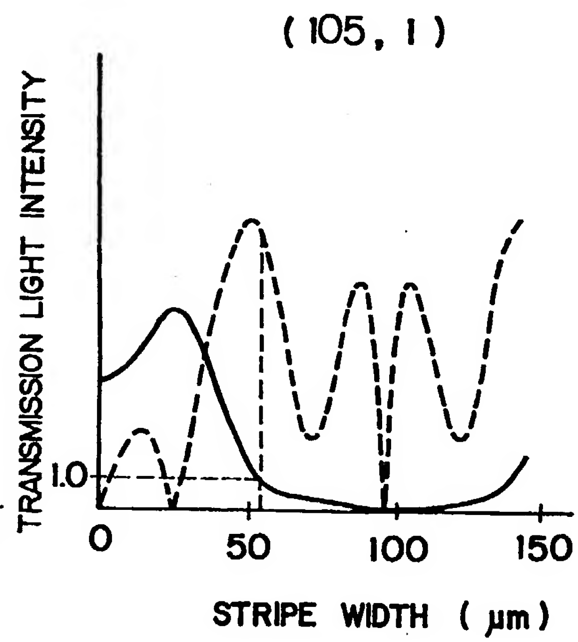


FIG. 7E

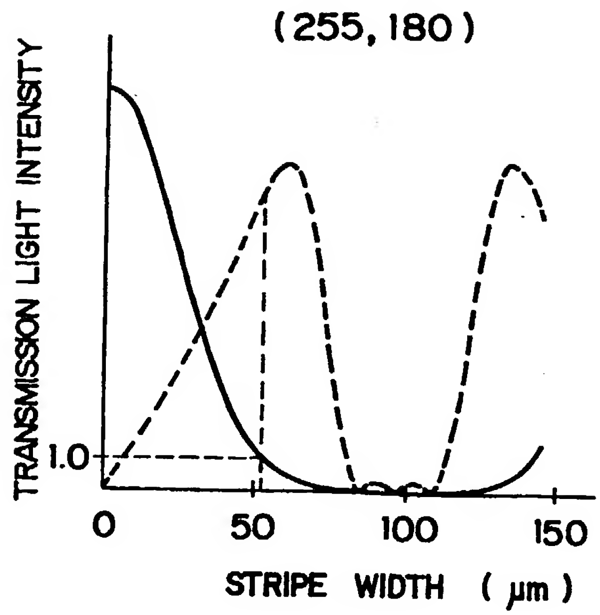
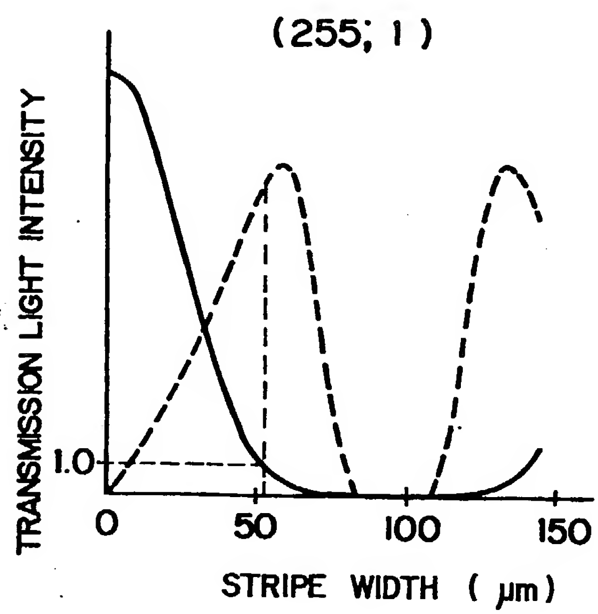

(255, 180)
TRANSMISSION LIGHT INTENSITY
1.0
0
50
100
150
STRIPE WIDTH (μm)

FIG. 7F


(255; 1)
TRANSMISSION LIGHT INTENSITY
1.0
0
50
100
150
STRIPE WIDTH (μm)